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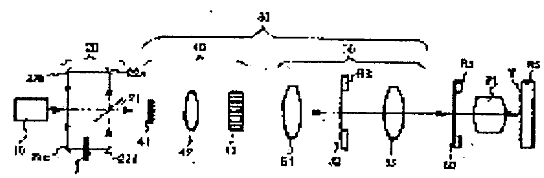
(54) ILLUMINATION OPTICAL DEVICE, ALIGNER COMPRISING THE SAME, AND METHOD FOR FABRICATING MICRODEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an illumination optical device in which the size can be reduced while suppressing coherence of a light source, an aligner comprising the illumination optical device, and a method for fabricating a microdevice comprising the aligner.
SOLUTION: Coherent light from a light source 10 is split by a half-mirror 21 and one part advances through an optical integrator system 40. The other part advances on a circulation optical path having an optical path length difference shorter than the coherence distance of the coherent light. It is then split again by the half-mirror 21 and the process is repeated. A deflection element 23 is a transparent optical element for deflecting light in a specified direction. Lights having a specified optical path length difference and a specified deflection angle and advancing through the optical integrator system 40 are mixed and passed through a light introduction system 30 before illuminating a reticle 60.



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CLAIMS

[Claim(s)]
[Claim 1] Illumination-light study equipment characterized by having the optical delay system which gives an optical-path-length difference shorter than the coherence length of said coherent light among said two or more division light, and the light guide system which leads the light from said optical delay system to an irradiated plane while dividing the light source which supplies a coherent light, and said coherent light and generating two or more division light.
[Claim 2] It is illumination-light study equipment according to claim 1 characterized by setting up shorter than the coherence length of said coherent light the optical-path-length difference between the n-th division light and the n+1st division light which advances a long optical path to the degree of said n-th division light when making n into the integer more than zero.
[Claim 3] Said optical delay system is illumination-light study equipment according to claim 1 or 2 characterized by having the deviation component of the transparency mold which deflects the light which carries out incidence.
[Claim 4] It is illumination-light study equipment which is equipped with the light source which supplies a coherent light, the optical delay system which gives a predetermined optical-path-length difference among two or more of said division light while dividing said coherent light and generating two or more division light, and the light guide system which leads the light from said optical delay system to an irradiated plane, and is characterized by for said optical delay system to have the transparency mold deviation component which deflects the light which carries out incidence.
[Claim 5] Said transparency mold deviation component is illumination-light study equipment according to claim 3 or 4 characterized by being the component from which the optical path length differs by the part.
[Claim 6] Said transparency mold deviation component is illumination-light study equipment according to claim 5 characterized by having a part where an optical-path-length difference becomes larger than lambda/10 when making lambda into the wavelength of said coherent light.
[Claim 7] It is illumination-light study equipment given in any 1 term of claims 3-6 which said transparency mold deviation component has two or more parts where the optical path lengths differ, and are characterized by the magnitude of said part being 1/2 or less [of the magnitude of the spatial coherence of said coherent light].
[Claim 8] Said optical delay system is illumination-light study equipment given in any 1 term of claims 1-7 characterized by having an optical division means to divide said coherent light and to generate said two or more division light, and the photomixing means which is made to mix said two or more division light, and is led to said light guide system.
[Claim 9] It is illumination-light study equipment according to claim 8 which said optical division means has the optical parting plane which makes said photomixing means serve a double purpose, has the circumference optical-path means forming which has two or more deviation sides in order that said optical delay system may form the circumference optical path which returns again the light divided by said optical parting plane to said optical parting plane, and is characterized by to be set up each deviation side in said circumference optical-path means forming, respectively so that said optical-path-length difference may give.
[Claim 10] Said reflector and said optical parting plane are illumination-light study equipment given in any 1 term of claims 1-7 characterized by being arranged so that an optical-path-length difference shorter than said coherence length may be given between the division light which goes to said light guide system from said optical parting plane including the optical parting plane by which opposite arrangement of said optical delay system was carried out with the reflector and this reflector by carrying out a multiple echo between said

reflectors and said optical parting planes.
[Claim 11] Said reflector and said optical parting plane are illumination-light study equipment according to claim 10 characterized by being arranged being un-parallel.
[Claim 12] Said optical delay system is illumination-light study equipment according to claim 10 or 11 characterized by including further the deviation component arranged between said reflectors and said optical parting planes.
[Claim 13] The light source which supplies a coherent light, and the optical delay system which gives a predetermined optical-path-length difference among said two or more division light while dividing said coherent light and generating two or more division light, It is illumination-light study equipment which is equipped with the light guide system which leads the light from said optical delay system to an irradiated plane, and is characterized by said optical delay system having the reflective mold deviation component which can adjust a deflection angle while deflecting light, and the transparency mold optical element which makes light diffuse or diffract.
[Claim 14] Said predetermined optical-path-length difference is illumination-light study equipment according to claim 13 characterized by being shorter than the coherence length of said coherent light.
[Claim 15] It is illumination-light study equipment given in any 1 term of claims 1-14 which have the optical integrator system which generates the-like secondary light source since said light guide system irradiates said irradiated plane at homogeneity, and are characterized by said optical integrator system forming 10,000 or more light source images in said-like secondary light source.
[Claim 16] The aligner characterized by having the illumination-light study system which changes from the illumination-light study equipment of a publication to any 1 term of claims 1-15, a mask maintenance means to set the mask which has a predetermined pattern as said irradiated plane, the projection optics which projects the pattern image of said mask on a photosensitive substrate, and a substrate maintenance means to hold said photosensitive substrate.
[Claim 17] The manufacture approach of the micro device which is the manufacture approach of the micro device using an aligner according to claim 16, and is characterized by having the process which applies sensitive material on said photosensitive substrate, the process which projects the image of the pattern of said mask through said projection optics on said photosensitive substrate, and the process which develops said sensitive material on said photosensitive substrate.

[Translation done.]

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2.**** shows the word which can not be translated.
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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the micro device using the illumination-light study equipment used in case micro devices, such as a semiconductor device, a liquid crystal display component, an image sensor, a CCD component, and the thin film magnetic head, are manufactured according to a lithography process, the aligner equipped with said illumination-light study equipment, and said aligner.
[0002]
[Description of the Prior Art] With the illumination-light study equipment used in case an above-mentioned device is manufactured, a laser beam is usually used as the light source. Since coherence of a laser beam is good, it is easy to generate an interference fringe and a speckle on an irradiated plane, and uniform lighting may not be obtained. Therefore, with conventional equipment, the optical path was divided, the optical-path-length difference more than the coherence length of light source light was given, and the coherence of light source light was reduced. There are some which were indicated by JP,1-198759,A as the example. Moreover, it equalizes, as the light which carries out outgoing radiation deviates from the above-mentioned optical path, whenever it carries out the above-mentioned optical path 1 round using a mirror etc., and he was trying to reduce the speckle on an irradiated plane. There are some which were indicated by JP,11-312631,A as the example.
[0003]
[Problem(s) to be Solved by the Invention] By the way, coherence length is mainly decided by wavelength and wavelength half-value width, and changes with the classes and wavelength half-value width of laser. For example, in the case of the wavelength of 248nm, and the excimer laser of wavelength half-value-width 0.6pm, time coherence length is set to about 200mm. In order to divide an optical path and to give the optical-path-length difference beyond such a distance, the optical system more than predetermined magnitude is needed. Moreover, if it is going to establish two or more optical paths which give such the optical path difference, equipment itself will surely become large. In realizing the miniaturization of equipment, from such a point, giving the optical-path-length difference more than coherence length has the 1st problem of becoming a failure.
[0004] Moreover, in order to give the predetermined optical path difference between each optical path divided into two or more optical paths, while each optical member which constitutes the optical system which gives the optical path difference is constituted with a sufficient precision, each optical member needs to be set up with a sufficient precision. However, there is the 2nd problem that it is difficult to finish setting up the optical system in which the adjustment at the time of a setup of each optical member appears very much and which it gives the optical path difference according to these constraints for a certain reason while it is difficult to manufacture each optical member which constitutes the optical system which gives the optical path difference for a short time.
[0005] It is in offering the manufacture approach of the micro device using the illumination-light study equipment which can realize the miniaturization of equipment, the aligner equipped with said illumination-light study equipment, and said aligner, this invention being made in view of such a problem, and the place first made into the 1st purpose concerning the 1st invention solving the 1st problem of the above, and reducing the coherence of the light source.
[0006] moreover -- while the place made into the 2nd purpose concerning the 2nd invention solves the 2nd problem of the above and the problem of coherence is reduced -- manufacture -- it is in offering the

manufacture approach of the micro device using easy illumination-light study equipment, the aligner equipped with said illumination-light study equipment, and said aligner.
[0007]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the illumination-light study equipment with which this invention is characterized by having the light source according to claim 1 which supplies a coherent light like, the optical delay system which gives an optical-path-length difference shorter than the coherence length of said coherent light among said two or more division light while dividing said coherent light and generating two or more division light, and the light guide system which leads the light from said optical delay system to an irradiated plane is offered. The miniaturization of equipment can be advanced by adopting the optical delay system which gives an optical-path-length difference shorter than the coherence length of light source light. As for the optical-path-length difference between the n+1st division light which advances an optical path long to the degree of the n-th division light and said n-th division light when [according to claim 2] making n into the integer more than zero like, in that case, it is desirable to be set up shorter than the coherence length of said coherent light. Moreover, as for said optical delay system, it is [like] desirable to have the deviation component of the transparency mold which deflects a light according to claim 3 which carries out incidence. Thereby, adjustment of the conventional mirror for a deviation and the mirror for a deviation becomes unnecessary, and an activity becomes easy. By the deviation component of a transparency mold, the light which carries out outgoing radiation from the divided optical path can be deflected, and can reduce the speckle on an irradiated plane. The thing using refraction or diffraction etc. can be considered as a component of a transparency mold.
[0008] According to another viewpoint of this invention, the light source according to claim 4 which supplies a coherent light like, The optical delay system which gives a predetermined optical-path-length difference among said two or more division light while dividing said coherent light and generating two or more division light, It has the light guide system which leads the light from said optical delay system to an irradiated plane, and the illumination-light study equipment characterized by said optical delay system having the transparency mold deviation component which deflects the light which carries out incidence is offered. by this, adjustment of an optical delay system can be boiled markedly, and can be made easy, and equipment can be manufactured in a short time. As for said transparency mold deviation component, in that case, it is [like] desirable that it is the component according to claim 5 from which the optical path length differs by the part. As this transparency mold deviation component, a diffracted-light study component etc. can be considered, for example. When [according to claim 6] making lambda into the wavelength of said coherent light, like and said transparency mold deviation component Like a publication [**** / constitute] to claim 7 so that it may have a part where an optical-path-length difference becomes larger than lambda/10 said transparency mold deviation component It has two or more parts where the optical path lengths differ, and if the magnitude of said part is constituted that it is 1/2 or less [of the magnitude of the spatial coherence of said coherent light], it can carry out the variation rate of the wave front of the light to penetrate effectively.
[0009] Moreover, you may constitute so that it may have the light division means according to claim 8 which said optical delay system divides said coherent light, and generates said two or more division light like, and the photomixing means which is made to mix said two or more division light, and is led to said light guide system. In that case, it has the light parting plane according to claim 9 said optical division means uses said photomixing means also [light] like, in order that said optical delay system may form the circumference optical path which returns again the light divided by said optical parting plane to said optical parting plane, it has the circumference optical-path means forming which has two or more deviation sides, and as for each deviation side in said circumference optical-path means forming, it is desirable to be set up, respectively so that said optical-path-length difference may be given. An equipment configuration can be simplified by making an optical division means and a photomixing means serve a double purpose. Moreover, including the optical parting plane according to claim 10 by which opposite arrangement of said optical delay system was carried out with the reflector and this reflector like, by carrying out a multiple echo between said reflectors and said optical parting planes, said reflector and said optical parting plane may be arranged so that an optical-path-length difference shorter than said coherence length may be given between the division light which goes to said light guide system from said optical parting plane. Space-saving-ization can be attained by using a multiple echo. In this case, like the publication to claim 11, said reflector and said optical parting plane may be arranged being un-parallel, and further, they may constitute so that the deviation component according to claim 12 by which said optical delay system has been arranged between said reflectors and said optical parting planes like may be included further.

[0010] According to another viewpoint of this invention, furthermore, the light source according to claim 13 which supplies a coherent light like, The optical delay system which gives a predetermined optical-path-length difference among said two or more division light while dividing said coherent light and generating two or more division light, It has the light guide system which leads the light from said optical delay system to an irradiated plane, and the illumination-light study equipment characterized by said optical delay system having the reflective mold deviation component which can adjust a deflection angle while deflecting light, and the transparency mold optical element which makes light diffuse or diffract is offered. As a transparency mold optical element, a thing like the phase plate from which the optical path length differs irregularly by the part can be considered, for example. Even if it can change irregularly the wave front of the light penetrated by using such a transparency mold optical element and the precision of include-angle adjustment of a reflective mold deviation component makes it loose, the coherency of light source light can be reduced as usual. Like the publication to claim 14 in that case, if said predetermined optical-path-length difference is constituted so that shorter than the coherence length of said coherent light, it can miniaturize equipment.
[0011] In addition, since [according to claim 15] said irradiated plane is irradiated in an above-mentioned light guide system at homogeneity, it has the optical integrator system which generates the-like secondary light source, and it is [like] desirable [said optical integrator system] to constitute so that 10,000 or more light source images may be formed in said-like secondary light source. An unnecessary interference fringe can be reduced by forming many light source images. As a component which constitutes this optical integrator system, a fly eye lens etc. can be considered, for example. Moreover, according to another viewpoint of this invention, the aligner characterized by having the illumination-light study system according to claim 16 which changes from the illumination-light study equipment of a publication to any 1 term of claims 1-15 like, a mask maintenance means to set the mask which has a predetermined pattern as said irradiated plane, the projection optics which projects the pattern image of said mask on a photosensitive substrate, and a substrate maintenance means to hold said photosensitive substrate is offered. Furthermore, the process which according to another viewpoint of this invention is the manufacture approach of the micro device using the aligner according to claim 16 like according to claim 17, and applies sensitive material on said photosensitive substrate, The manufacture approach of the micro device characterized by having the process which projects the image of the pattern of said mask through said projection optics on said photosensitive substrate, and the process which develops said sensitive material on said photosensitive substrate is offered.
[0012]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail based on a drawing. In addition, in the following explanation and an accompanying drawing, duplication explanation is omitted by attaching the same sign about the component which has the function and configuration of abbreviation identitas.
[0013] Drawing 1 is the block diagram of the aligner concerning the gestalt of operation of the 1st of this invention. In order of the optical path, the light source (light source section) 10, the optical delay system 20, the light guide system (illumination-light study system) 30, and the reticle 60 are arranged. The light guide system 30 consists of the optical integrator system 40 and the capacitor optical system 50. Here, although for example, KrF excimer laser (oscillation wavelength: 248nm), ArF excimer laser (oscillation wavelength: 193nm), or F2 laser (oscillation wavelength: 158nm) can be used for the light source 10 as the light source section, it can supply a coherent light and that can be used for it by any light sources. Moreover, the relay system for taking about the beam plastic surgery system and optical path which are changed into the flux of light which has the magnitude and the cross-section configuration of a request of the flux of light which carries out incidence in the optical path between the light source 10 and the optical delay system 20 or the optical path between the optical delay system 20 and the light guide system (illumination-light study system) 30 etc. can also be arranged.
[0014] In addition, it not only constitutes only from a refraction mold optical element, but each above optical system can be constituted from combination of a refraction mold optical element and a reflective mold optical element only by the configuration or the reflective mold optical element.
[0015] The light source 10 is the light source which supplies a coherent light. The light which carried out outgoing radiation of the light source 10 goes into the optical delay system 20. The optical delay system 20 has the half mirror 21 which functions as an optical division member (partial reflection mirror of an amplitude-splitting mold) of an amplitude-splitting mold, the reflective mirrors 22a, 22b, 22c, and 22d, and the deviation component 23. Here, the half mirror 21 has a predetermined reflection factor and predetermined, predetermined permeability, and divides them into the transmitted light and the reflected light under a predetermined ratio. In

addition, the permeability of a half mirror 21 is not restricted in 50%, but, as for the value of the permeability of a half mirror 21, it is desirable that it is smaller than the value of the reflection factor of a half mirror 21. The reflective mirrors 22a, 22b, 22c, and 22d are set up so that the light which carries out incidence may be deflected in the predetermined direction and a circumference optical path may be formed. And the optical path length d of this circumference optical path is constituted so that it may become shorter than the time coherence length Lc of the light of the light source 10. The deviation component 23 is an optical element of the transparency mold which has the function to deflect light in the predetermined direction, as explained in full detail later.
[0016] The light from the light source goes into the optical delay system 20 first, carries out incidence to a half mirror 21, and is divided into the transmitted light and the reflected light. The transmitted light progresses to the optical integrator system 40. The reflected light enters in a circumference optical path, is deflected with the deviation component 23 within a circumference optical path, carries out incidence to a half mirror 21 again, and is further divided into the reflected light and the transmitted light. It is mixed in accordance with the same optical path as the light which penetrated the half mirror 21 first, and the reflected light which it was furthermore divided and was produced progresses to the optical integrator system 40. The transmitted light which it was furthermore divided and was produced progresses again, and carries out incidence of the optical path in the optical delay system 20 to a half mirror 21, it is further divided into the reflected light and the transmitted light, and it is performed repeatedly that it is the same as that of ****.
[0017] Incidence of the light which carried out incidence to the optical integrator system 40 is carried out to the order of the 1st integrator 41, the relay optical system 42, and the 2nd integrator 43. The 1st integrator 41 and the 2nd integrator 43 consist of the aggregate of many lens elements here, and form the light source image of the-like secondary light source in an outgoing radiation side. The unnecessary interference fringe in an irradiated plane is reduced, so that there are many these light source images. It consists of gestalten of this operation so that 10,000 or more light source images may be formed. Then, incidence of the light from this light source image is carried out to the capacitor optical system 50, it illuminates the reticle conjugation side 52 by the 1st lens group 51, and illuminates mostly the reticle 60 which is an irradiated plane to homogeneity by the 2nd lens group 53. And image formation of the predetermined pattern formed on the reticle 60 is carried out to the photosensitive substrates W (wafer etc.) by projection optics PL, and the predetermined pattern image of a reticle 60 is exposed on Substrate W.
[0018] Here, a reticle 60 is held in a reticle stage RS, and Substrate W is held on the substrate stage WS. Moreover, in order to specify the lighting field on a reticle 60 (or the exposure field on Substrate W convention), the reticle blind (field diaphragm) RB which has opening of the shape of a predetermined rectangle is set up, and it is good for the reticle conjugation side 52 also considering the magnitude of opening of this reticle blind RB as adjustable. Therefore, the 2nd lens group 53 functions as image formation optical system which carries out image formation of the opening of a reticle blind RB on a reticle 60.
[0019] In addition, the 1st integrator 41 and the 2nd integrator 43 can consist of rod mold integrators (the prism member of an internal reflection mold, centrum material of an internal reflection mold, etc.) of the fly eye lens formed with the aggregate of many lens elements, the micro fly eye lens formed with the aggregate of many micro lenses and a Fresnel lens or a diffracted-light study component, and an internal reflection mold as a member of each type. The 1st integrator 41 and the 2nd integrator 43 may combine the member of a type which may consist of members same type or is different.
[0020] Especially, in order to make the original resolution and the original depth of focus which projection optics PL has in recent years improve, the so-called zona-orbicularis lighting and the multi-electrode lighting which made the configuration of the secondary light source the multi-electrode configuration which carried out eccentricity from the zona-orbicularis configuration or the core attract attention. What is necessary is just to give a function which is changed into the 1st integrator 41 at the zona-orbicularis-like flux of light, in order to correspond to this. Therefore, for example, the 1st integrator 41 The integrator component usually for lighting which makes a secondary light source configuration a circular configuration, If it considers as the configuration by which one of integrator components is inserted into an optical path including the integrator component for the zona-orbicularis lighting which makes a secondary light source configuration a zona-orbicularis configuration, and the integrator component for multi-electrode lighting which makes a secondary light source configuration a multi-electrode configuration The request according to the optimal reticle pattern which should be exposed can be illuminated alternatively.
[0021] Moreover, if the relay optical system 42 arranged between two integrators is constituted from variable

power optical system, a coherence factor (sigma value: ratio of the magnitude of the secondary light source formed in the pupil of the projection optics over the magnitude of the pupil of projection optics) can also be made adjustable by making magnitude of the secondary light source adjustable.
[0022] Below, an optical delay system is described in detail. A half mirror 21 is penetrated without carrying out outgoing radiation of the light source, and passing along a circumference optical path at all, and light which progresses to the optical integrator system 40 is set to L0. After carrying out outgoing radiation of the light source, reflecting by the half mirror 21 and carrying out a circumference optical path 1 round, light which progresses to the optical integrator system 40 is set to L1. After carrying out outgoing radiation of the light source, reflecting by the half mirror 21, carrying out a circumference optical path 1 round, penetrating a half mirror 21 and carrying out a circumference optical path 1 round, a circumference optical path is carried out 2 round, and light which progresses to the optical integrator system 40 is set to L2. Similarly, ... and light carried out n round are set to L3, L4, ..., Ln for a circumference optical path 3 rounds and 4 round. Since the optical path length of a circumference optical path is d, all the optical-path-length differences of L1, L2, L2, L3, ... and Ln-1, and Ln are d, and this is shorter than the coherence length Lc of light source light.
[0023] Since it is easy, the case of $Lc/2<d<Lc$ is considered. Since L1, L2, L2 and L3, and the optical-path-length difference of the group of the light from which an optical-path-length difference differs by the 1 circumference like ... are shorter than Lc, the group of such light interferes. However, like L1, L3 and L2, L4, L3 and L5, and ..., the optical-path-length difference of the group of the light from which an optical-path-length difference differs by the 2 circumference is 2d, and since it is longer than Lc, the group of such light does not interfere. Since similarly the optical-path-length difference of the light from which an optical-path-length difference differs more than a 3-round batch is also longer than Lc, the group of such light does not interfere. Therefore, only the group of the light from which an optical-path-length difference differs by the 1 circumference interferes, and the group of other light does not interfere. Although interference of the group of the light from which an optical-path-length difference differs by the 1 circumference could be regarded as the interference in false 1 beam and this is generated also with conventional equipment, it is thought that it is practically completely satisfactory.
[0024] Here, an effective light as illumination light is considered. Since light is divided into the transmitted light and the reflected light by the half mirror 21 whenever it carries out a circumference optical path 1 round, only in the part of the light which penetrates the light after L2 by the half mirror 21, the quantity of light decreases. That is, the quantity of light decreases in L2, L3, L4, ..., Ln, and order. The light with too little quantity of light is invalid as illumination light. Therefore, although light progresses an infinity time circumference optical path theoretically, actually effective one as illumination light becomes the light which progressed the number of finite times about a circumference optical path.
[0025] Although said count of finite is based on the components engine performance and specification of equipment, the place depended on the reflection factor of a half mirror 21 is large especially. By setting up the reflection factor of a half mirror 21 well, the class of effective light as illumination light can be increased. For example, the place whose light from L0 to L3 was effective is made for the light from L0 to L7 to become effective by setup of the reflection factor of a half mirror 21 in the former. Thereby, in the former, by four sorts of light, when the speckle pattern is equalized, a speckle pattern can be equalized using eight sorts of light.
[0026] Therefore, the coherence of the light source can be reduced as usual by setting up the reflection factor of a half mirror 21 well, when the circumference optical path length shorter than coherence length is taken, and increasing the class of effective light as illumination light. Since it is not necessary to take a circumference optical path more than coherence length, the miniaturization of equipment becomes easy. Here, although the case of $Lc/2<d<Lc$ was explained since it was easy, it cannot limit to this and this invention can be applied about the thing of $d<Lc$.
[0027] Next, the deviation component 23 is explained. As the deviation component 23 is shown in drawing 2 here, a cross section is a rectangle-like diffracted-light study component. The optical path lengths differ, and this optical-path-length difference h consists of the optical paths A and optical paths B of drawing so that it may become large from lambda/10. Moreover, magnitude D of the rectangle section is constituted so that it may become 1/2 or less [of the magnitude of the spatial coherence of the light source 10]. From this, a wave front displaces effectively the light which carried out incidence to the deviation component 23, and it carries out outgoing radiation with a predetermined include angle according to the principle of diffraction. That is, the light which carried out incidence to the deviation component 23 is deflected. When the deviation component 23 consists of diffracted-light study components which have a periodic pitch here, D is the one half of the pitch of

a diffracted-light study component, and when the deviation component 23 consists of random pattern components, D is the one half of the average pitch of a random pattern component.
[0028] Therefore, outgoing radiation of the light which carried out outgoing radiation from the light source is carried out from the optical delay system 20 with an include angle predetermined whenever it carries out a circumference optical path 1 round. From this, since the light which carries out incidence to the optical integrator system 40 inclines, the speckle in an irradiated plane can shift and the contrast of a speckle pattern can be reduced. By leaning a mirror, light was deflected, the speckle shift was performed and the mirror include angle needed to be tuned finely of the former. However, with the gestalt of this operation, the pitch of the diffracted-light study component of the deviation component 23 performs adjustment of the deflection angle of light. What is necessary is to adjust and check the travelling direction of light, where the deviation component 23 is removed, and just to install the deviation component 23 in a predetermined location after that, in case alignment is performed as initial setting of equipment. The complicated activity of fine tuning of the conventional mirror include angle becomes unnecessary by using the component of the pitch set up at the time of a design and manufacture, and the effectiveness that the deflection angle of a desired light can set up easily is acquired.
[0029] Drawing 3 shows the cross-section configuration of another example of the deviation component 23. Here, a deviation component is the diffracted-light study component 231 of a blaze configuration (serration configuration). In the case of this component, since about 100% of the light which carried out incidence turns into the diffracted light, light can be deflected efficiently. In addition, the diffracted-light study component of a blaze configuration is good also as a configuration to which the slant face is curving (the shape of a curved surface), without restricting to that from which a slant face turns into a flat surface, as shown in drawing 3 .
[0030] Drawing 4 shows the cross-section configuration of still more nearly another example of the deviation component 23. Here, the deviation component consists of wedge-shaped prism 232, and deflects light not by diffraction but by refraction. In the case of this component, there is the advantage in which manufacture is very easy compared with two above-mentioned components.
[0031] The example of the optical delay system which starts the gestalt of operation of the 2nd of this invention at drawing 5 is shown. Since it differs from the gestalt of the 1st operation of only an optical delay system with the gestalt of this operation, below, only an optical delay system is explained. Here, light is divided and the polarization beam splitter 24 is used instead of the half mirror 21 as a means to mix. In this example, lambda/2 plate 26a is further arranged between the light source 10 and the optical delay system 20, and Lenses 25a and 25b and lambda/2 plates 26a and 26b are further arranged in the circumference optical path of the optical delay system 20. The optical path length d of this circumference optical path is constituted so that it may become shorter than the coherence length Lc of the light of the light source 10.
[0032] First, the light which carried out outgoing radiation of the light source 10 penetrates lambda/2 plate 26a. By rotating lambda/2 plate 26a, light can be changed into a predetermined polarization condition. Then, incidence of the light is carried out to a polarization beam splitter 24, it is divided into P polarization and S polarization, and is penetrated and reflected, respectively. Reflected S polarization progresses to the optical integrator system 40. After transmitted P polarization progresses a circumference optical path and penetrates lens 25a, it is deflected with the deviation component 23 and penetrates lens 25b. And incidence is carried out to lambda/2 plate 26b, a polarization condition changes by this, incidence is again carried out to a polarization beam splitter 24, it is again divided into P polarization and S polarization, and the same thing is performed repeatedly. Thus, advance of division of light and the circumference optical path of division light is performed like the case where a half mirror 21 is used.
[0033] Two lenses (25a, 25b) arranged in the circumference optical path here image formation optical system -- constituting -- **** -- for example, the deviation beam splitter 24 -- almost -- the point of a center position dividing [optical] -- P1 -- carrying out -- a deviation component, if the point in a center position is mostly set to P2 Lens 25a (the 1st relay optical system) carries out image formation of the point P1 to a point P2, and lens 25b (the 2nd relay optical system) carries out image formation of the point P2 to a point P1. Therefore, image formation optical system (25a, 25b) is carrying out re-image formation of the polarization separation side (optical parting plane) of a polarization beam splitter (optical division member) 24 through the circumference optical path. If it puts in another way, image formation optical system (25a, 25b) makes conjugate optically the polarization separation side (optical parting plane) of a polarization beam splitter (optical division member) 24, and the polarization separation side (optical parting plane) of the polarization beam splitter (optical division member) 24 through a circumference optical path.

[0034] At this time, as for the image formation scale factor of image formation optical system (25a, 25b), it is desirable that it is actual size, and, as for the image formation scale factor of lens 25a (the 1st relay optical system) and lens 25b (the 2nd relay optical system), it is more desirable respectively that it is actual size. However, if it is not necessary to make the image formation scale factor of lens 25a (the 1st relay optical system) and lens 25b (the 2nd relay optical system) into actual size and the image formation scale factor of image formation optical system (25a, 25b) not necessarily serves as actual size, the image formation scale factor of lens 25a (the 1st relay optical system) and lens 25b (the 2nd relay optical system) can be made into arbitration. For example, what is necessary is just to make the image formation scale factor of lens 25b (the 2nd relay optical system) into 1/2, if it is twice the image formation scale factor of lens 25a (the 1st relay optical system) of this.
[0035] In addition, it cannot be overemphasized that it is applicable to the example list shown in drawing 1 thru/or drawing 4 also in the example described below, without restricting image formation optical system (25a, 25b) to this example. The optical system for interference fringe prevention which does not have big effect on the engine performance according to the above image formation optical system (25a, 25b) even if include-angle gap arises can be constituted. Therefore, when the large light source of an angle of divergence is used, dotage of a beam does not occur by the angle of divergence.
[0036] With the gestalt of the 1st operation, the coherence of the light source was reduced by setup of the reflection factor of a half mirror 21. With the gestalt of this operation, it resembles rotating lambda/2 plates 26a and 26b and a polarization beam splitter 24, and more, the rate of the reflected light and the transmitted light can be changed and the same effectiveness as the gestalt of the 1st operation is acquired. Although adjustment of a reflection factor was not completed by after installation since the reflection factor of a half mirror was immobilization when a half mirror was used in addition to it, with the gestalt of this operation, the rate of the reflected light and the transmitted light is not immobilization, and can be changed easily. Therefore, it can apply also to experimental use and can optimize at the time of actual use. For example, changing the use light source etc. can respond flexibly, when conditions change, and it has composition with a high degree of freedom.
[0037] The example of the optical delay system which starts the gestalt of operation of the 3rd of this invention at drawing 6 is shown. Since it differs from the gestalt of the 1st operation of only an optical delay system with the gestalt of this operation, below, only an optical delay system is explained. Here, instead of reflective mirror 22b of the gestalt of the 1st operation, and the deviation component 23, the tilt mirror 27 and the random phase plate 28 are arranged. The tilt mirror 27 is a mirror which can adjust the deflection angle while deflecting light. Here, the tilt mirror 27 is formed possible [an inclination] two-dimensional, as shown in drawing 6 , for example, an operator can adjust the amount of inclinations to the inclination direction list of the tilt mirror 27 through the mechanical leaning device (tipper) TS. The random phase plate 28 is an optical element which has the part where the optical path lengths differ irregularly. The cross-section configuration of the example is shown in drawing 7 .
[0038] Although the light which advances the circumference optical path of an optical delay system is deflected by the tilt mirror 27 and carries out outgoing radiation from an optical delay system, it receives diffusion or a diffraction operation with the random phase plate 28 in that case. Since the random phase plate 28 has the part where the optical path lengths differ irregularly, the diffusion or a diffraction operation will also become irregular rather than is uniform. Therefore, even if it does not make strict adjustment precision of the deflection angle of the tilt mirror 27 like before, the coherency of the illumination light finally obtained can be reduced as usual. Therefore, according to the gestalt of this operation, the effectiveness that adjustment of the tilt mirror 27 for optical deflections becomes easy is acquired. In addition, although drawing 6 showed the example which prepared one tilt mirror, it cannot be overemphasized that two or more tilt mirrors may be prepared.
[0039] The example of the optical delay system which starts the gestalt of operation of the 4th of this invention at drawing 8 is shown. Since it differs from the gestalt of the 1st operation of only an optical delay system with the gestalt of this operation, below, only an optical delay system is explained. With the gestalt of this operation, the multi-beam optical system which used the multiple echo for the optical delay system is adopted. Here, as shown in drawing, the travelling direction of the light which comes out of the light source 10 is made into the direction of z, the direction perpendicular to it of facing up in space is made into the direction of y, and the direction perpendicular to space is made into x directions.
[0040] The light which carried out outgoing radiation of the light source 10 goes into the multi-beam optical system 29 which is an optical delay system. The light which the multi-beam optical system 29 has partial reflection mirror (optical parting plane) 29b by which opposite arrangement was carried out with total reflection

mirror (reflector) 29a and total reflection mirror 29a, and carried out incidence to the multi-beam optical system 29 is changed into the beam group which was located in a line in the direction of y so that it might explain in full detail later and which consists of a beam of parallel a large number mutually. Then, by the contraction system 31, a beam group has the effective diameter of the direction of y reduced, and carries out incidence to the diffusion plate 33 through the depolarization prism 32. The emission light from the diffusion plate 33 progresses to the optical integrator system 41, and is the same as that of the gestalt of the 1st operation after that. Moreover, the arrangement made the same as the gestalt of the 1st operation of the optical system after the diffusion plate 33 is also possible. That is, the configuration which removes the diffusion plate 33 and the optical integrator system 41 of drawing 8 , instead arranges a micro fly eye lens, a Fresnel lens, a diffracted-light study component, and a rod mold integrator is also possible. However, it is desirable to design so that it may become smaller than each beam diameter in which the division unit of each above-mentioned component constitutes the multi-beam which carries out incidence from this arrangement. Since each above-mentioned component can make a division unit very small, this design is possible. Moreover, it is possible to carry out deformation lighting by giving the function to generate zona-orbicularis lighting and multi-electrode lighting to the above-mentioned component, like the gestalt of the 1st operation.

[0041] Next, the multi-beam optical system 29 is explained to a detail, referring to drawing 9 . The multi-beam optical system 29 has total reflection mirror 29a and partial reflection mirror 29b, and, as for these, only an include angle theta inclines to the direction of y, it is almost parallel mutually, and each reflector is arranged so that it may counter. The light T0 which carried out incidence to the multi-beam optical system 29 along the direction of y is divided into the transmitted light and the reflected light by partial reflection mirror 29b, the transmitted light T1 progresses to the contraction system 31, and the reflected light goes to total reflection mirror 29a. And the light reflected by total reflection mirror 29a is again divided further into the transmitted light T2 and the reflected light toward partial reflection mirror 29b. The transmitted light T2 progresses to the contraction system 31, and the reflected light goes to total reflection mirror 29a. The light which the same thing was repeated and carried out incidence to the multi-beam optical system 29 hereafter is divided into two or more beams T0, T1, --, Tn to which the predetermined optical-path-length difference was given by carrying out a multiple echo between total reflection mirror 29a and partial reflection mirror 29b. Here, since total reflection mirror 29a and partial reflection mirror 29b are arranged so that it may have an inclination to the direction of y, an outgoing radiation beam serves as a beam group which was mostly located in a line in the direction of y at equal intervals and which consists of a beam of parallel a large number mutually. In addition, since it is easy by a diagram, only several beams were expressed, the remaining beams were omitted and the thickness of total reflection mirror 29a and partial reflection mirror 29b has been disregarded.

[0042] Here, if spacing of a mirror is set to d, adjoining Beam Ti and the optical-path-length difference of Ti-1 will be set to about 2d. And it is constituted so that these 2d may become shorter than the time coherence length Lc of light. Thus, by arranging two components, total reflection mirror 29a and partial reflection mirror 29b, the light from the light source 10 can be divided into two or more light, and a predetermined optical-path-length difference can be given.

[0043] Therefore, since the beam of a large number from which an optical-path-length difference differs laps according to the gestalt of this operation, the condition of a wave front changes for every optical-path-length difference in those lap condition, and the spatial coherence in a beam cross section is reduced on the average. That is, an interference light unnecessary as an aligner can be erased. Moreover, the tooth space of the direction of an optical axis can be saved. Furthermore, compared with the gestalt of other above-mentioned operations, the gestalt of this operation is easy to constitute and also has the advantage that there are few components mark.

[0044] Next, the 1st modification of the gestalt of this operation shown in drawing 10 is explained. In this modification, only an include angle alpha is shifted a little in the direction which showed the relative include angle of total reflection mirror 29a of drawing 9 , and partial reflection mirror 29b from parallel to drawing 10 , and it is made arrangement of a wedge. Thereby, an outgoing radiation beam is not parallel but has an include angle mutually, and whenever i of spacing of the adjoining beam Ti and the direction of y of Ti-1 increases, the effective diameter of the direction of y of a beam group becomes small as narrowing and a result. Therefore, in addition to the effectiveness of coherence reduction, in this modification, the effectiveness of space-saving-izing about the direction of y is also acquired. In order to adjust an include angle alpha, total reflection mirror 29a is energized by elastic members, such as a spring, a piezo-electric element can be contacted from the opposite side, and it can tune finely by carrying out the seal of approval of the electrical potential difference to

a piezo-electric element suitably. Or you may make it use a micrometer instead of a piezo-electric element. A coarse control should just move the whole mirror. In addition, drawing 10 is a mimetic diagram, and the include angle of a beam of light etc. is emphasized and drawn. Moreover, since it is easy by a diagram, only several beams were expressed, the remaining beams were omitted and the thickness of total reflection mirror 29a and partial reflection mirror 29b has been disregarded.
[0045] Next, the 2nd modification of the gestalt of this operation shown in drawing 11 is explained. In this modification, as shown in drawing 9 , after carrying out adjusting arrangement of the spacing of total reflection mirror 29a and partial reflection mirror 29b almost in parallel as d, the deviation component 23 is inserted between total reflection mirror 29a and partial reflection mirror 29b. In addition, the deviation component to insert can use the prism 232 grade of the wedge shape shown in the diffracted-light study component 23 of the shape of a rectangle as shown in drawing 2 , the diffracted-light study component 231 of the blaze configuration shown in drawing 3 , or drawing 4 . Light is deflected by the deviation component 23 and can make small the effective diameter of the direction of y of a beam group like a modification 1 by it. Therefore, in addition to the effectiveness of coherence reduction, in this modification, the effectiveness of space-saving-izing about the direction of y is also acquired. Moreover, in the case of this modification, adjustment of total reflection mirror 29a and partial reflection mirror 29b becomes easy. When a diffracted-light study component is inserted especially, a wave-front configuration changes at every reflection, and it becomes still more effective in reduction of spatial coherence. In addition, since it is easy by a diagram, the thickness of total reflection mirror 29a and partial reflection mirror 29b is disregarded, and the diffracted-light study component 23 is drawn typically.
[0046] Next, the 3rd modification of the gestalt of this operation shown in drawing 12 is explained. This modification forms the rectangle-like diffracted-light study component 230 in the reflector of total reflection mirror 29a beforehand instead of insertion of the deviation component 23 in the 2nd modification. Light is deflected by the diffracted-light study component 230, and can make small the effective diameter of the direction of y of a beam group like a modification 1 by it. Therefore, in this modification, while a wave-front configuration changes at every reflection and spatial coherence is reduced, the effectiveness of space-saving-izing about the direction of y is also acquired. Moreover, by having unified the diffracted-light study component 230 as total reflection mirror 29a and a deviation component, components mark can be lessened compared with the 2nd modification, and manufacture and adjustment are easy. In addition, you may make it form the diffracted-light study component 230 not only in total reflection mirror 29a but in partial reflection mirror 29b. In addition, since it is easy by a diagram, the thickness of total reflection mirror 29a and partial reflection mirror 29b is disregarded, and the diffracted-light study component 230 is drawn typically.
[0047] Next, the aligner concerning the gestalt of the 5th operation by this invention is explained, referring to drawing 13 . The example shown in drawing 13 tends to acquire further the reduction effectiveness of an interference fringe or a speckle which increases one optical delay system 20 shown in drawing 1 , and is produced in a reticle or a substrate. The point that the example shown in drawing 1 differs from drawing 13 is a point which has arranged a depolarizer 103, the relay optical system 102, the 1st light delay unit 104, the 2nd light delay unit 105, and the beam expander 106 between the laser light sources 101, such as excimer laser, and the 1st integrator 171. In addition, a depolarizer 103 cancels the effect of polarization from a laser light source 101, and is indicated in JP,11-174365,A, JP,11-312631,A, etc.
[0048] As for the laser beam from a laser light source 101, optical delayed action is given in order by the optical delay system which contains two optical delay units (104,105) through a mirror M1, a depolarizer 103, a mirror M2, the relay optical system 102, and a mirror M3.
[0049] So that the optical-path-length difference of the laser beam given in the 1st light delay unit 104 may become more than the coherence length Lc of a laser beam here So that the optical-path-length difference of the laser beam which each optical member which constitutes the 1st light delay unit 104 is arranged by predetermined relation, and is given in the 2nd light delay unit 105 may become shorter than the coherence length Lc of laser Each optical member which constitutes the 2nd light delay unit 105 is arranged by predetermined relation like the optical delay system 20 of drawing 1 . by this, the 2nd light delay unit 105 can be boiled markedly, and it can constitute in a compact. Or it may constitute so that the optical-path-length difference of the laser beam given in the 1st light delay unit 104 may become shorter than the coherence length of a laser beam, and you may constitute so that the optical-path-length difference of the laser beam given in the 2nd light delay unit 105 may become more than the coherence length Lc of a laser beam. Or it cannot be overemphasized that you may constitute so that the optical-path-length difference of the laser beam given in

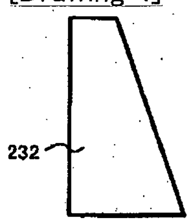
both optical delay units (104,105) may become shorter than the coherence length Lc of a laser beam. In addition, an optical delay system is good also as a configuration possessing three or more optical delay units, and can also omit a depolarizer 103 in this case.
[0050] Now, the laser beam through an optical delay system (104,105) illuminates a reticle 109 to homogeneity through a mirror M4, the beam expander 106 as beam plastic surgery optical system, a mirror (M6, M7), the optical integrator system 107, and the capacitor optical system 108, and the lighting field of the shape for example, of a slit is formed on the reticle 109. Projection exposure of the partial pattern of the reticle 109 illuminated in the shape of a slit is carried out through projection optics 110 at the substrates 111, such as a wafer. In this case, a reticle 109 is held in a non-illustrated reticle stage, the substrate 111 is held on the non-illustrated substrate stage, and imprint exposure of the pattern of the whole surface of a reticle 109 is carried out on a substrate 111 through projection optics 110 by moving a reticle 109 and a substrate 111 in the predetermined direction (the direction of a short hand of a slit-like lighting field) through a reticle stage and a substrate stage.
[0051] In addition, the optical integrator system 107 has the 1st integrator 171 and the 2nd integrator 172. Although drawing 13 shows the example which constituted each integrator (171,172) from a fly eye lens, these may consist of a micro fly eye lens, a diffracted-light study component, or a rod-like optical member of an internal reflection mold. Moreover, although the mirror for an optical-path deviation (M8, M9) is arranged inside each [of the optical integrator system 107 and the capacitor optical system 108], the mirror M8 inside the optical integrator system 107 consists of oscillating mirrors (galvanomirror) which scan the reflected light in a slight amount, in order to prevent the interference fringe and speckle which are generated with a reticle 109 and a substrate 111 with an optical delay system (104,105).
[0052] In addition, this invention is applicable to the equipment which could apply to the illumination-light study system for exposure of each type, for example, was indicated in the Europe patent public presentation official report EP 1014196A2 (a open day: June 28, 2000). the zona orbicularis to which the equipment indicated in the Europe patent public presentation official report EP 1014196A2 makes a zona-orbicularis ratio adjustable continuously in zona-orbicularis lighting -- a ratio -- it is further constituted combining the plurality of a micro-lens array, a diffracted-light study component, prism, a fly eye lens, the glass rods, etc. including the good light variation study system and the sigma value good light variation study system which makes a lighting sigma value adjustable continuously. In the above-mentioned Europe patent public presentation official report the optical delay system (20 29,104,105) of this invention The light source 1 in drawing 1 , and an exchangeable micro-lens array The optical path between (4, 40), the optical path between the light sources 1 and the axicon prism (6 6a) in drawing 12 , the optical path between the light sources 1 and the diffracted-light study components (6b, 6c) in drawing 16, the optical path between the light sources 1 and diffracted-light study component 6b in drawing 21, The light source 1 and axicon prism in drawing 22 The optical path between (6, 6a), the optical path between the light sources 601 and the diffracted-light study components 604 in drawing 23, the optical path between the light source 701 in drawing 29, and an exchangeable optical element (751-756), the light source 1001 in drawing 43, and an exchangeable diffracted-light study component It can arrange to the optical path between (1004, 1004b, 1004c) etc.
[0053] Moreover, the optical delay system (20 29,104,105) of this invention is applicable also to the equipment indicated to JP,11-271619,A (a open day: October 8, 1999). the zona orbicularis which gives the operation changed into the zona-orbicularis flux of light which has a predetermined zona-orbicularis ratio to exposure light with the equipment which indicated to this JP,11-271619,A, for example as shown in drawing 1 -- a ratio -- while giving the operation which changes into 4 aurora bundles to the adjustable system 3 and exposure light, it has the 4 aurora bundles adjustable system 4 which can adjust the location of 4 aurora bundles, and a configuration containing optical integrators (an internal-reflection mold integrator etc.). In this JP,11-271619,A, the optical delay system (20 29,104,105) of this invention can be arranged to the optical path between the zona-orbicularis ratio adjustable systems 3 etc. as the light source 1 in drawing 1 .
[0054] Drawing 14 is a flow chart which shows an example of the actuation at the time of manufacturing a micro device using the aligner equipped with the illumination-light study equipment concerning the gestalt of each operation of this invention stated above. First, in step 101, a metal membrane is vapor-deposited on the wafer of one lot. In the following step 102, a photoresist is applied on the metal membrane on the wafer of the one lot. Then, in step 103, the sequential exposure imprint of the image of the pattern on a reticle (60,109) is carried out through the projection system using said aligner to each shot field on the wafer (W, 111) of the one lot. Then, in step 104, after development of the photoresist on the wafer of the one lot is performed, in step

105, the circuit pattern corresponding to the pattern on a reticle 60 is formed in each shot field on each wafer by etching by using a resist pattern as a mask on the wafer of the one lot. Then, devices, such as a semiconductor device which has a very detailed circuit, are manufactured by forming the circuit pattern of the upper layer further.
[0055] As mentioned above, although the suitable operation gestalt concerning this invention was explained referring to an accompanying drawing, it cannot be overemphasized that this invention is not limited to this example. If it is this contractor, it will be clear that it can hit on an idea for various kinds of examples of modification or examples of correction in the criteria of the technical thought indicated by the claim, and it will be understood as what naturally belongs to the technical range of this invention also about them.
[0056]
[Effect of the Invention] As mentioned above, as explained to the detail, after reducing the coherence of the light source as usual according to this invention, the aligner equipped with the illumination-light study equipment which can miniaturize equipment, and said illumination-light study equipment can be offered. furthermore -- being unnecessary in the complicated activity of fine tuning of the mirror include angle which was the need conventionally -- carrying out -- the deflection angle of a desired light -- easy -- a setup -- possible -- manufacture -- the aligner equipped with easy illumination-light study equipment and said illumination-light study equipment can be offered. Moreover, according to another viewpoint of this invention, the manufacture approach of the micro device using said aligner can be offered.

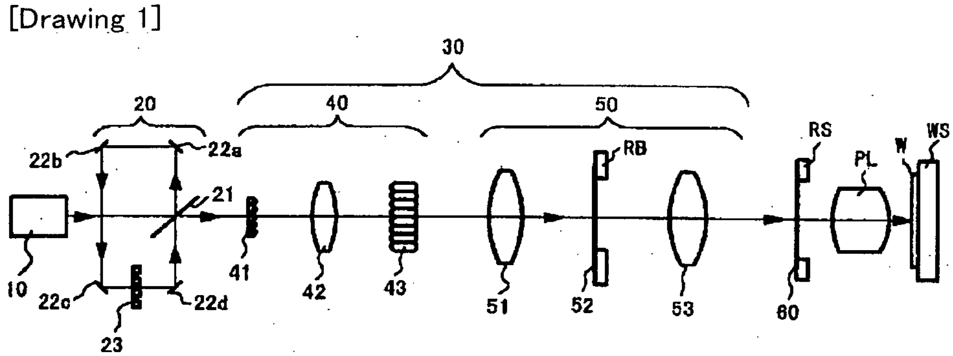
[Translation done.]

DRAWINGS

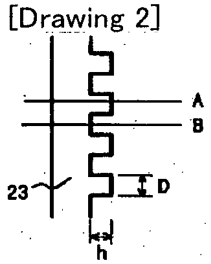
[Drawing 4]



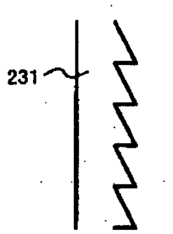
[Drawing 1]



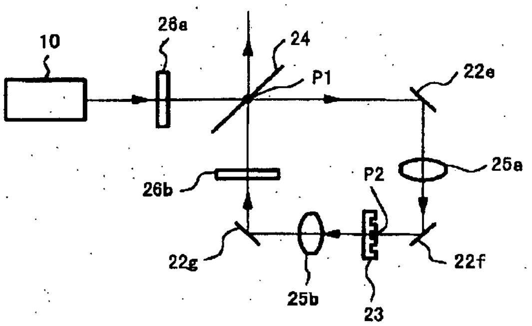
[Drawing 2]



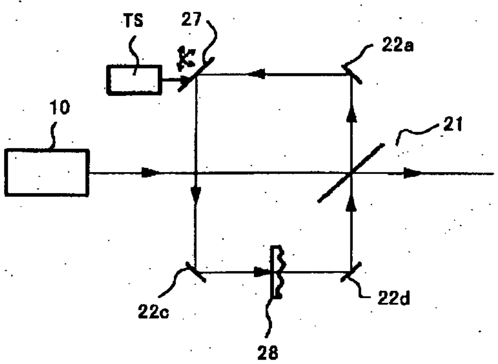
[Drawing 3]



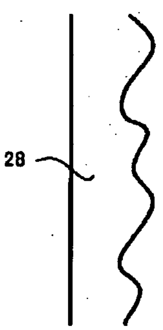
[Drawing 5]



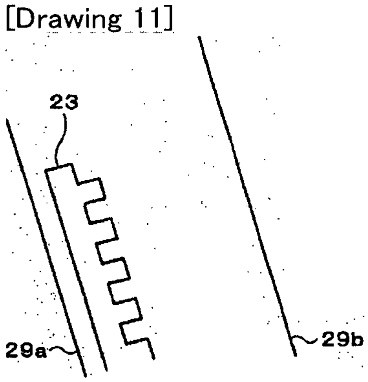
[Drawing 6]



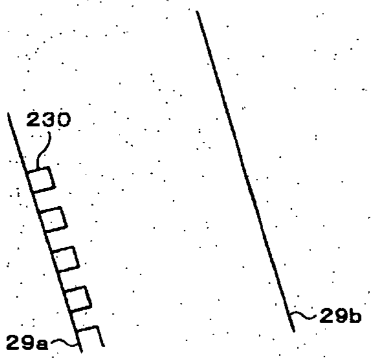
[Drawing 7]



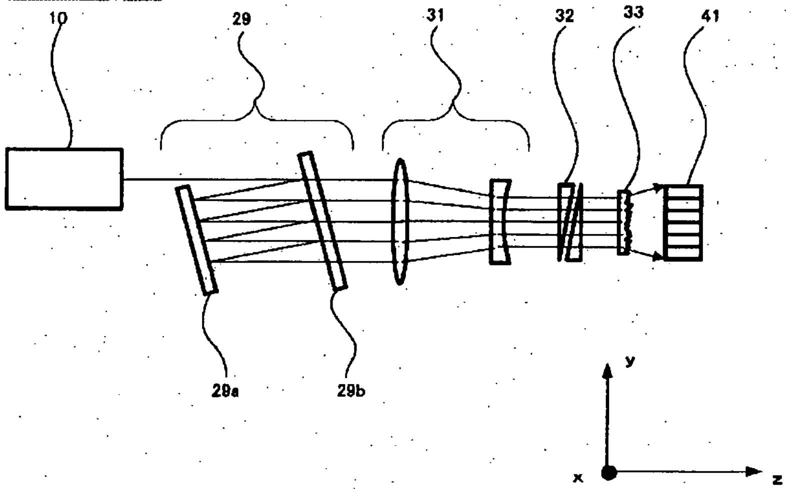
[Drawing 11]



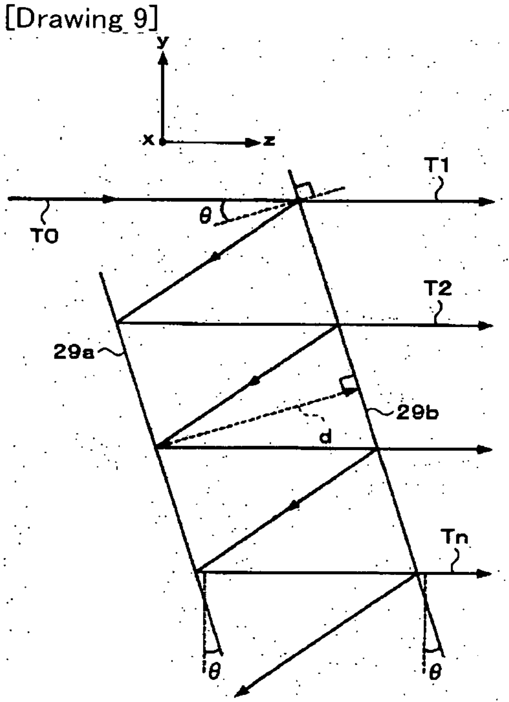
[Drawing 12]



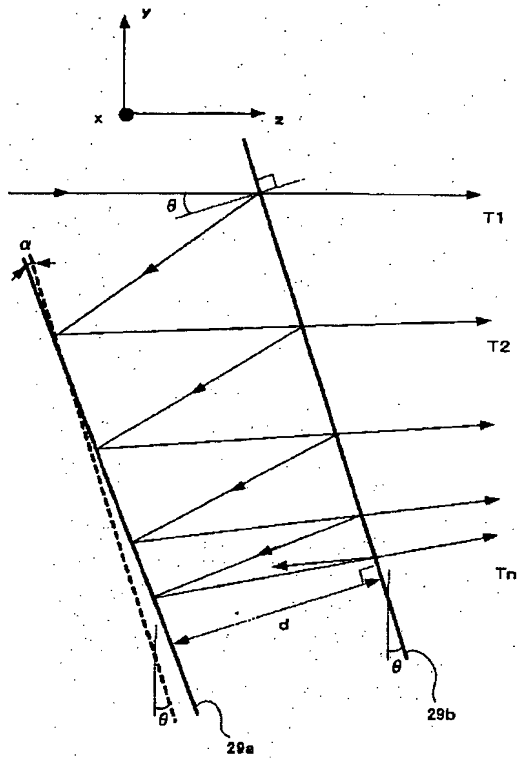
[Drawing 8]



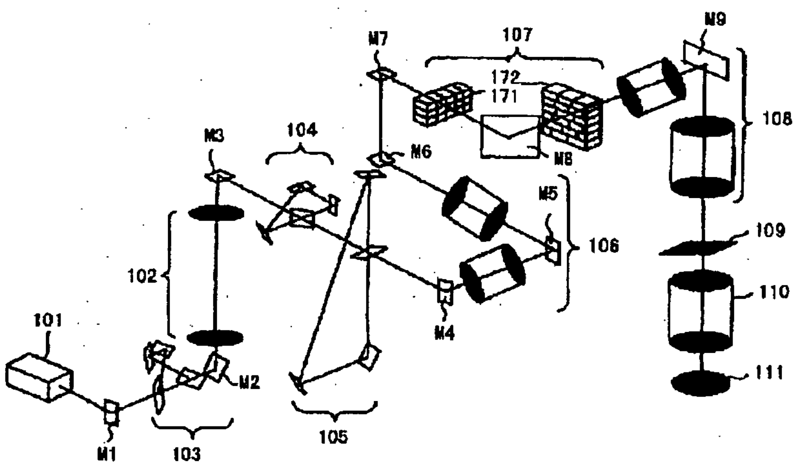
[Drawing 9]



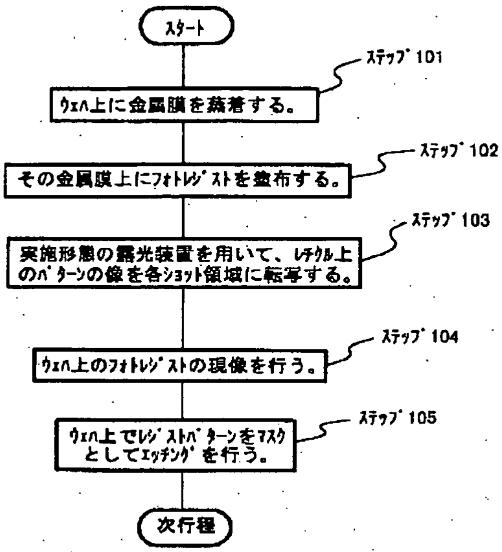
[Drawing 10]



[Drawing 13]



[Drawing 14]



[Translation done.]